WHAT IS CLAIMED IS:

1. A molecular rotary nanomotor comprising, as structural components:

```
a gp10 connector protein;
```

a gp8 capsid protein; and

a non-naturally occurring pRNA;

wherein the structural components are associated with one another to form a nanoscale structure that effects translocation of a polynucleotide in the presence of a gp16 protein, ATP and Mg⁺⁺.

- 2. The molecular nanomotor of claim 1 wherein the non-naturally occurring pRNA is one that folds into a structure similar to that of naturally occurring phi29 pRNA (SEQ ID NO: 2).
- 3. The molecular nanomotor of claim 1 further comprising a protein gp7.
- 4. The molecular nanomotor of claim 1 wherein the translocation activity can be reversibly stopped by contacting the nanomotor with a metal chelating agent, contacting the nanomotor with a nonhydrolyzable ATP analogue, or depriving the nanomotor of a source of gp16 protein, ATP or Mg⁺⁺.
- 5. An isolated molecular nanomotor comprising as structural components:

a connector protein;

a capsid protein; and

a pRNA;

wherein the structural components are associated with one another to form a nanoscale structure that effects translocation of a polynucleotide in the presence of ATP and Mg⁺⁺, and wherein the pRNA binds ATP and drives the rotational motion of the nanomotor.

- 6. The isolated molecular nanomotor of claim 5 wherein the pRNA is selected from the group consisting of SF5 pRNA (SEQ ID NO: 5), B103 pRNA (SEQ ID NO: 6), M2/NF pRNA (SEQ ID NO: 7) and GA1 pRNA (SEQ ID NO: 8).
- 7. The isolated molecular nanomotor of claim 5 wherein the pRNA folds into a structure similar to that of naturally occurring pRNA from SF5, B103, M2/NF or GA1.
- 8. The isolated molecular nanometer of claim 5 wherein the pRNA is a non-naturally occurring pRNA.
- 9. A method for translocating a polynucleotide comprising:

providing a molecular nanomotor having a nanoscale structure according to any of claims 1-8; and

contacting the nanoscale structure with a gp16 protein, ATP and Mg⁺⁺ under conditions to translocate the polynucleotide.

- 10. The method of claim 9 wherein the contacting step further comprises contacting the nanoscale structure with polyethylene glycol.
- 11. The method of claim 9 further comprising contacting the nanoscale structure with a chelating agent or a nonhydrolyzable ATP analogue to reversibly stop translocation of the polynucleotide.
- 12. The method of claim 11 wherein the chelating agent is EDTA.
- 13. The method of claim 11 wherein the nonhydrolyzable ATP analogue is γ -S-ATP.